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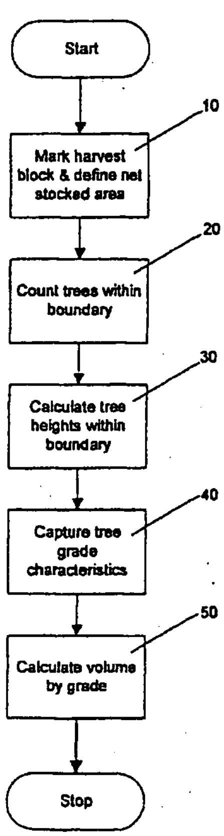
[Continued on next page]

(54) Title: METHOD OF ASSESSING STANDING TREES



(57) Abstract: The invention provides a method of assessing standing trees comprising the steps of defining an area of forest for assessment containing a plurality of standing trees, calculating the number of trees within the defined area, measuring characteristics of one or more trees within the defined area, and defining an assessment indicator of the standing trees based on the number and characteristics of the standing trees. The invention also provides a method of measuring characteristics of one or more trees comprising the step of calculating a plurality of spatial co-ordinates defining the surface of at least part of the tree(s). The invention also provides related apparatus for measuring characteristics of one or more trees.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD OF ASSESSING STANDING TREES

FIELD OF INVENTION

The invention relates to a method of assessing standing trees. The invention could be used for performing pre-harvest assessments, forest inventory and forest description surveys of forestry blocks. The invention could also be used for assessing the carbon content of standing trees for assessing the capability of the trees to absorb carbon dioxide.

BACKGROUND TO INVENTION

Forestry companies have historically operated in what is known as a plant-to-market model in which a single forestry company is responsible for planting, harvesting, processing and marketing plantation forests. Over the last few years there has been a shift in the industry to forestry companies buying and selling mature forests. It has become particularly important to develop a method for determining timber value in mature forests for ascertaining a purchase or sale price. It has also become more important to develop efficient harvest management practices and also to be able to demonstrate environmentally friendly forestry practices and forest sustainability.

One method of assessing a harvest prior to harvesting for determining timber value involves calculating a volume by grade (log characteristics) which involves marking a forest boundary defining a woodlot boundary, defining a net stocked area, counting the number of trees within the boundary that area and the average height of these trees. Further assessments by "forest cruising" are also made to determine the DBH or diameter at breast height (DBH) and a grade profile. The grade profile is affected by characteristics of the trees in the area such as the size and position of branches and the sweep indicating the extent of curvature in the tree stems. Information from the above processes are entered into a grade optimising model such as "MARVL" or "Tree Tools" to determine wood volume by grade outturn.

Volume by grade values are currently difficult to determine due largely to inaccurate net stocked area estimations and the field definition marking of boundaries during harvesting in which there is typically a 10% error. A further difficulty is that characteristics such as the number of trees within a woodlot and the grade profile are currently extrapolated on small samples and are estimated to contribute to about 30%-40% error.

Agreements such as the Kyoto Protocol call on some countries to conserve and enhance sinks and reservoirs to help reduce greenhouse gas concentrations in the atmosphere. Sinks are any natural or man made system that absorb and store greenhouse gases, mainly carbon dioxide. An expanding or growing forest is a sink where carbon dioxide is absorbed and stored in the wood as carbon.

Government agencies, forestry companies, industries and other parties are required to establish the baseline carbon content of an area of forest, and then track changes in the carbon volumes over time. A growing forest will attract carbon credits, and a harvested forest will attract carbon debits. It is necessary to provide a credible system for measurement of carbon value for the trading of credits on domestic or international trading markets and to provide confidence in the ratification of the Kyoto Protocol.

Volumes for carbon within a tree are currently difficult to determine due largely to inaccurate locations of the boundaries of a forest area and the variability of a location and distribution of the trees within that forest area. A further difficulty is that characteristics such as stem dimensions and branching are currently extrapolated on small samples. These difficulties can result in significant volume error.

It is known to use aircraft-mounted integrated mapping sensors, for example film based cameras, four channel high resolution digital multispectral frame cameras, channel high resolution digital hyperspectral sensors, and co-located lasers or EM profilers. Such systems also includes remote sensing algorithms and photogrammetric processes to derive information from the aircraft sensors in order to assess standing trees for harvesting and/or carbon content.

It is, however, difficult to apply these systems effectively unless the boundaries under assessment are accurately marked. Furthermore, it is also necessary to calculate further characteristics of trees within a block to calculate the volume by grade by field measurements as aerial surveys alone will not necessarily provide accurate values for DBH and other characteristics.

SUMMARY OF INVENTION

In one form the invention comprises a method of assessing standing trees comprising the steps of defining an area of forest for assessment containing a plurality of standing trees, calculating the number of trees within the defined area, measuring characteristics of one or more trees within the defined area, and defining an assessment indicator of the standing trees based on the number and characteristics of the standing trees.

In another form the invention comprises a method of measuring characteristics of one or more trees comprising the step of calculating a plurality of spatial co-ordinates defining the surface of at least part of the tree(s).

In a further form the invention comprises measuring apparatus for measuring characteristics of one or more trees, the measuring apparatus configured to calculate a plurality of spatial co-ordinates defining a surface of at least part of the tree(s) and to store the spatial co-ordinates in a memory.

BRIEF DESCRIPTION OF THE FIGURES

Preferred forms of the method of assessing a harvest will now be described with reference to the accompanying figures in which:

Figure 1 is a flow chart of a preferred form of calculating wood volume by grade in accordance with the invention;

Figure 2 shows a method of marking boundaries in accordance with the invention;

Figure 3 shows one method of data capture through aerial surveys;

Figure 4 shows the analysis of digital images captured from the aerial survey of Figure 3;

Figure 5 shows a field-based tree profiler used in accordance with the invention;

Figure 6 illustrates image processing of the images captured with the device of Figure 5;

Figure 7 illustrates tree profiling from data captured from Figures 5 and 6;

Figure 8 shows a further preferred form of performing assessments of carbon volumes in forests or indigeous bush; and

Figure 9 shows an image captured in assessing the leaf area index.

DETAILED DESCRIPTION OF PREFERRED FORMS

Figure 1 illustrates one application of the invention in assessing trees for performing pre-harvest assessments (PHA) of plantation forests. As indicated at 10, an area of harvest for assessment is defined by determining the boundary of the woodlot and the net stocked area within by photogrammetric methods and marking the boundaries around the perimeter of that area. One problem with existing blocks of mature forests is that it is difficult to determine accurately the correct position of the boundaries defining the forest, also to record this boundary over time. This difficulty is particularly apparent where legal boundaries are not clearly defined by physical features such as streams and roads. It is particularly important to establish the correct boundaries at the time of each survey for a forest to avoid the significant costs associated with cutting down trees

outside of a forest allotment, or mistakenly leaving trees standing which are within a forest allotment.

Historically, some forestry companies have marked out particular boundaries by dropping "paint bombs" from a light aircraft or helicopter. The invention provides a new method of marking boundaries by dropping radio transmitting beacons from a helicopter as will be described below.

As indicated at step 20, the trees are then counted within the area marked by the boundaries of step 10 above. In the past, forestry companies have calculated an estimate of the number of stems in a plantation woodlot by marking out a small sample plots100 metre by 100 metre square, counting the stems in that square plot, and extrapolating this figure over the area of the plantation woodlot. It is envisaged that known hardware such as the QuickMap Smart Forests system designed by Asia Pacific Systems Engineering (APSE) in combination with tree-counting algorithms developed by, for example Landcare Research and Melbourne University, be be used to accurately count the number of trees within the defined area.

Referring to step 30, tree heights within the defined area are optionally calculated. Once again, using known film based cameras and/or photogrammetric processes or laser/EM profilers, the heights of the trees can be calculated during the same aerial survey as that used for counting the trees, as will be more particularly described below.

In order to calculate an assessment indicator of the harvest, for example volume by grade, it is also necessary to capture tree attribute profiles of trees within the boundary. Such tree attribute profiles are necessary to obtain data such as DBH (diameter at breast height) and other characteristics such as the size and placing of tree branches and assessments of stem straightness. One way of capturing such information is to use a ground-based "tree attribute profiler" (TAP) which is a 3-dimensional laser distance measurement device. Laser beams are directed toward each tree and from the reflected signals, the tree attribute profiler calculates a plurality of spatial co-ordinates or points which define the surface of part of the tree under assessment.

As indicated at step 50, an assessment indicator for example the volume by grade of the forest woodlot is then calculated based on the data gathered from steps 10, 20, 30 and 40 above within a wood volume by grade optimisation model.

The step of marking and/or locating the boundaries is further described with reference to Figure 2. We have found that forestry companies require many non-professionals to enter the forests from time to time, for example to harvest, maintain or plant a particular area, or to obtain measurements of profiles of trees within the area. These persons will not always have the ability to determine exactly where the legal boundaries lie for a particular forest or area.

Using a helicopter 100, it is possible to position a series of radio transmitters or beacons, one of which is indicated at 110, defining the perimeter of a forest 120. The preferred transmitters are low cost devices which can be dropped accurately from helicopter 100. Preferably the helicopter 100 is provided with a differential GPS positioning system to accurately position each transmitter. It is preferable to drop each transmitter from the helicopter 100 in such a way that the transmitter 100 drops through the tree canopy and rests on the ground beneath the tree canopy. Alternatively where GPS signals can be received under the tree canopy, field positioning of the beacons by the use of GPS receivers can be undertaken.

Each transmitter or beacon is preferably a battery-operated low cost device with a long life. Each beacon preferably includes one or more unique identifying codes. These codes could include different forms of signal which could be detected with a ranging device 130 operated by a user 140 within a range of up to 5 to 10 kilometers.

A ground-based user equipped with a ranging device 130 is able to quickly locate the area within the boundaries defined by the beacons by traversing the perimeter using each uniquely identified beacon as a marker. In this way, logging, harvesting, planting, and/or tree profiling can be performed entirely within the correct area.

A transmitter can also be placed by hand in a convenient location such as track or clearing. A receiver or ranging device may be able to be directed to a calculated specific point by triangulating from three or more such transmitters.

Referring to Figure 3, the trees within a boundary are counted preferably using a known system. An aircraft 200 has mounted on it a film based camera or multispectral frame camera, for example a four channel high resolution digital multispectral frame camera, or a 256 channel high resolution digital hyperspectal sensor.

It is envisaged that the four channel multi-spectral digital camera is set for the three standard RGB bands and a fourth near infrared (NIR) channel.

Preferably the plane 200 is equipped with an integrated kinematic positioning system, which uses differential GPS technology received in real time from regional satellite rebroadcasts of the GPS correction signals. The differential GPS information is recorded together with accurate pitch, roll and yaw information derived from a digital inertial navigation sensor together with an accurate time reference.

Tree heights within the defined area could be calculated at the same time as the counting process. It is envisaged that a vertical laser profiler (LIDAR) is also mounted on aircraft 20. The laser profiler directs laser beams down onto the forest within the area under assessment. Preferably the LIDAR directs laser signals at a rate of 20,000 pulses per second.

The laser profiler obtains reflective signals from the upper surfaces of trees in the area and also from the ground surface beneath the trees whenever the laser signals penetrate the tree canopy. From the differences in the reflected signals, the laser profiler calculates the heights of trees within the defined area.

In a further preferred form, the system could include an electromagnetic profiler mounted on aircraft 200. Unlike the laser profiler, the electromagnetic profiler is able to penetrate the tree canopy and reflect off the bare ground surface and sub-surface

structures such as rocks. Such an electromagnetic profiler is useful for mapping features in order to plan harvesting tracks and skid sites in a mature forest in circumstances where there are no existing adequate contour maps.

Referring to Figure 4, the system produces a series of digital images, for example image 300. Tree counting algorithms such as algorithms produced by Landcare Research and Melbourne University, segment each image 300 to highlight individual tree crowns, one of which is indicated at 310. The remotely sensed tree counting process can also be determined using photogrammetry or a vertical laser profiler (LIDAR) to count the stems. Further image segmentation separates out the number of trees in image 310 ready for automatic counting.

Results outside New Zealand in tropical multi-species forest have been found to achieve 95% accuracy using a multi-spectral camera and the Melbourne TIDA tree counting algorithms. It is envisaged that the invention, when applied to regularly spaced single specifies forests, will achieve at least 95% accuracy.

The invention further includes the step of capturing tree attribute profiles or measuring characteristics of trees within the boundary. Referring to Figure 5, a user positions a field-based tree attribute profiler indicated at 400 close to a tree 410 to be profiled. The tree profiler 400 is a 3-dimensional laser distance measurement device or land-based laser emitter which directs laser beams 420 toward the tree 410 and records the laser beams 430 reflected from the tree 410. The preferred profiler 400 is arranged to direct laser beams 420 to consecutive elevations of the tree surface 410.

From the reflected laser beams 430, the profiler 400 captures a series of spatial (x,y,z) co-ordinates defining the surface of the tree 410.

Referring to Figure 6, raw scan tree images obtained by the profiler 400 are indicated at 500 and 510. From the raw scan images 500 and 510, the series of spatial co-ordinates are obtained and displayed as indicated at 520 and 530 and extracted from the overall image as indicated at 540 and 550.

In use, the profiler 400 is positioned close to a standing the tree 410 and leveled. The profiler 400 scans the tree 410 and generates a 3-dimensional digital terrain model comprising a series of spatial co-ordinates from which a user can derive any dimensions or characteristics required. The user could derive, for example, detailed measurements for tree diameter at any point of the tree including DBH or diameter at breast height, stem length measurement to determine the various sections for each grade of wood quality, wood volume calculations and stem straightness.

Referring to Figure 7, for example, the spatial co-ordinates of a tree are indicated at 600. These spatial co-ordinates at height 610, for example, will define an arc representing the surface of the tree at point 610 which is visible to the profiler 400. A series of arcs can be obtained in this manner for points 620, 630 and 640. The circumference of the tree stem at points 610, 620, 630 and 640 can then be obtained from the arcs and represented for example at 650.

Each of the diameter representations shown at 650 will have a centroid represented by a spatial co-ordinate which in practice represents the centre of the trunk at one of the capture points. By comparing the spatial positions of the centroids of each circle 650, the system is able to assess the degree of curvature or sweep in the tree stem.

The size and positioning of the branches can also be obtained from the spatial co-ordinate models of the trees to provide an indication of internode lengths of tree stems.

Individual trees can be scanned in 1-3 minutes using the tree profiler. Preferably a sample of trees in a forest will be scanned using a statistically robust model to determine sample locations, such as has been developed by Forest Research. Using the tree profiler, it is not unrealistic to scan 3% of all trees as a sample of the tree population. Preferably the tree samples include trees sited in diverse areas of a forest area. It is envisaged that the tree sample would include trees sited in valleys, trees sited on bridges, trees sited on north-facing slops, and trees sited on south-facing slopes.

A further advantage of the tree attribute profiler is that a digital image and spatial co-ordinates are obtained for individual trees and stored in a memory. In this way it is possible to review and audit the measurement results which has not normally been available with other forest cruising procedures. We have found that historically forestry companies have experienced a 20%-30% calculation error in tree attribute profiling. It is anticipated that the tree profiler will be significantly more accurate, 10-20 times more thorough, than historical cruising techniques.

Using the woodlot boundary determination, net stocked area determination, boundary marking, tree counting, tree heighting, and tree profiling techniques and a grade optimising model described above, forestry companies can define highly accurate assessment indicators for example wood volume estimation calculations by grade. It is envisaged that the same invention could be used with harvest management in which forestry blocks are checked to provide information on the amount of logging performed to date and also the amount left. The invention also provides accurate locations of roads, landings and contours which provides a forestry company with an estimation of the actual usable land area with unusable features land area removed from the calculation. It is further envisaged that a forestry company could predict the growth of trees by obtaining information about the growth profile of the trees. This growth profile could provide a basis for assessment of trees at an early stage. For example, if it is unlikely that a forestry block will return a profit once it is matured, a forestry company may wish to harvest the trees prior to maturity, thereby avoiding significant losses. The invention provides a method of obtaining information about this growth profile.

Figure 8 illustrates another application of the invention in performing assessments of carbon volumes in forests or indigenous bush. A site location 700 is first defined by locating the boundaries around the perimeter of that area in the manner described above by dropping or otherwise placing radio transmitting beacons in the area. It is particularly important to establish the correct boundaries at the time of each survey for a forest to provide accurate assessments of carbon in a forest in a reliably repeatable way, as the carbon sink credits will be dependent on changes in the assessment.

As shown at 710, an aerial carbon sink survey is conducted and a site map computed at 720. Species of individual trees within the site location are identified as shown at 730.

As shown at 740, the trees are then counted within the area marked by the boundaries of step 700 above. The tree heights within the defined area may optionally be calculated at step 750. As shown at 760, characteristics such as the surface area can be computed and as shown at 770, tree health measurements can be computed.

In order to calculate an assessment indicator of the carbon volume, for example tonnes per tree, it is also necessary to capture tree profile attributes of trees within the boundary, as indicated at 780. Such tree profiles are necesssary to obtain data of characteristics such as stem dimensions and the size and number of tree branches. As shown at step 790, the volume of carbon in the forest is then calculated based on the data gathered from the above within a model that relates tree characteristics to the carbon volume within the tree.

Where a tree attribute profiler is used to generate spatial co-ordinates, a user could derive from these co-ordinates detailed measurements for a tree at any point of the tree including diameter, stem length, branch size and wood volume calculations.

Referring to Figure 9, information related to the leaf area index of a tree can be captured preferably using an aerial mounted 256 channel high resolution digital hyper spectral sensor. The sensor receives light 800 reflected from the leaves of a tree 810 and captures data that provides a measure of the photosynthesising capacity of a tree.

The leaf area index is a measure of the ability of the tree to photosynthesize carbon dioxide gases and store the carbon within the tree. Preferably this method would be used to assess the carbon content of trees over an entire forest area and preferably the tree attribute profiler would be used to assess the content of carbon of trees in sample areas within the forest. Preferably the tree attribute profiler model would provide calibration and ground proofing for the aerial hyperspectral model.

Using the boundary identification, tree counting, tree heighting, tree profiling techniques and leaf area index assessment described above, government agencies, forestry companies, industries and other parties can make highly accurate carbon content assessments based on wood volume.

As an alternative to or in addition to the tree attribute profiler, it is also envisaged that the crown size of trees within an area be calculated from aerial photographs. The ground size of the tree is related to the volume of wood in that tree and the volume of wood in that tree can be calculated from the crown size. The tree attribute profiler is a sample based tool, whereas the volume from crown size obtained from aerial photographs can measure every tree.

It is also envisaged that the density of standing trees be calculated. A suitable hand held tool when held against the trunk of a tree, with the bark removed, would give an instant readout of the density of the wood in the stem. Carbon content assessments could then be based on wood volume data obtained through such a tool.

It is also anticipated that the hyperspectral camera used with the invention could be configured to pick up certain diseases or crop types. This would enable a user to identify specific species, noxious weeds, make an assessment on plant health, and locate and map environmental contaminants.

The foregoing describes the invention including preferred forms thereof. Alterations and modifications as will be obvious to those skilled in the art are intended to be incorporated, as defined by the accompanying claims.

CLAIMS

1. A method of assessing standing trees comprising the steps of:
defining an area of forest for assessment containing a plurality of standing trees;
calculating the number of trees within the defined area;
measuring characteristics of one or more trees within the defined area; and
defining an assessment indicator of the standing trees based on the number and characteristics of the standing trees.

2. A method of assessing standing trees as claimed in claim 1 wherein the step of defining an area of a forest for assessment further comprises the step of positioning a series of transmitters to define the perimeter of the area.

3. A method of assessing standing trees as claimed in claim 2 wherein one or more of the transmitters includes one or more unique identifying codes.

4. A method of assessing standing trees as claimed in any one of the preceding claims wherein the step of calculating the number of trees within the defined area further comprises the steps of capturing a series of images of the area from an aerial survey and performing image processing on the captured images.

5. A method of assessing standing trees as claimed in any one of the preceding claims wherein the step of measuring characteristics of one or more trees further comprises the step of calculating a plurality of spatial co-ordinates defining the surface of at least part of the tree(s).

6. A method of assessing standing trees as claimed in claim 5 wherein the step of measuring characteristics further comprises the step of calculating, from the spatial co-ordinates, the diameter of a tree at one or more heights.

7. A method of assessing standing trees as claimed in claim 5 or claim 6 wherein the step of calculating a plurality of spatial co-ordinates comprises the step of directing a laser beam towards the tree from a land-based laser emitter.

8. A method of assessing standing trees as claimed in any one of the preceding claims further comprising the step of estimating the heights of a plurality of standing trees within the defined area.

9. A method of assessing standing trees as claimed in claim 8 wherein the step of estimating the height of a plurality of trees within the area further comprises the steps of:

directing a laser beam down toward the area from an aircraft-mounted laser emitter;

sensing laser signals reflected upward from elevated surfaces of trees within the area;

sensing laser signals reflected upward from the surface beneath the trees; and

calculating the height of one or more of the trees based on the differences between reflected laser signals.

10. A method of assessing standing trees as claimed in claim 8 or claim 9 wherein the step of estimating the height of a plurality of trees within the area further comprises the step of using photogrammetric processes to determine height.

11. A method of measuring characteristics of one or more standing trees comprising the step of calculating a plurality of spatial co-ordinates defining the surface of at least part of the tree(s).

12. A method of measuring characteristics of one or more trees as claimed in claim 11 further comprising the step of calculating, from the spatial co-ordinates, the diameter of a tree at one or more heights.

13. A method of measuring characteristics of one or more trees as claimed in claim 11 or claim 12 wherein the step of calculating a plurality of spatial co-ordinates comprises the step of directing a laser beam toward the tree from a land-based laser emitter.

14. Measuring apparatus for measuring characteristics of one or more trees, the measuring apparatus configured to calculate a plurality of spatial co-ordinates defining a surface of at least part of the tree(s) and to store the spatial co-ordinates in a memory.

15. Measuring apparatus as claimed in claim 14 comprising a land-based laser emitter configured to direct a laser beam towards a tree in order to calculate a plurality of spatial co-ordinates defining a surface of at least part of the tree.

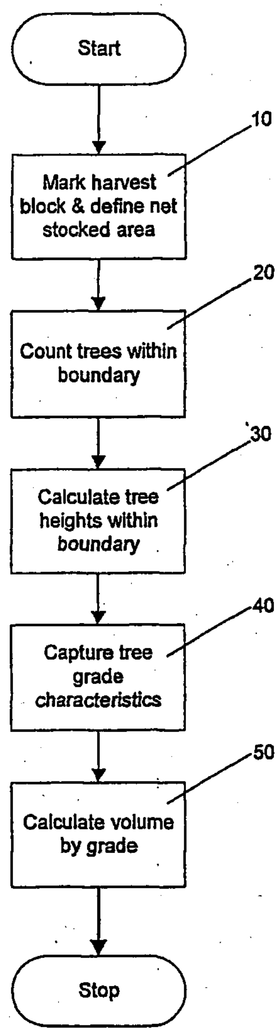
Start
10
Mark harvest block & define net stocked area
20
Count trees within boundary
30
Calculate tree heights within boundary
40
Capture tree grade characteristics
50
Calculate volume by grade
Stop

FIGURE 1

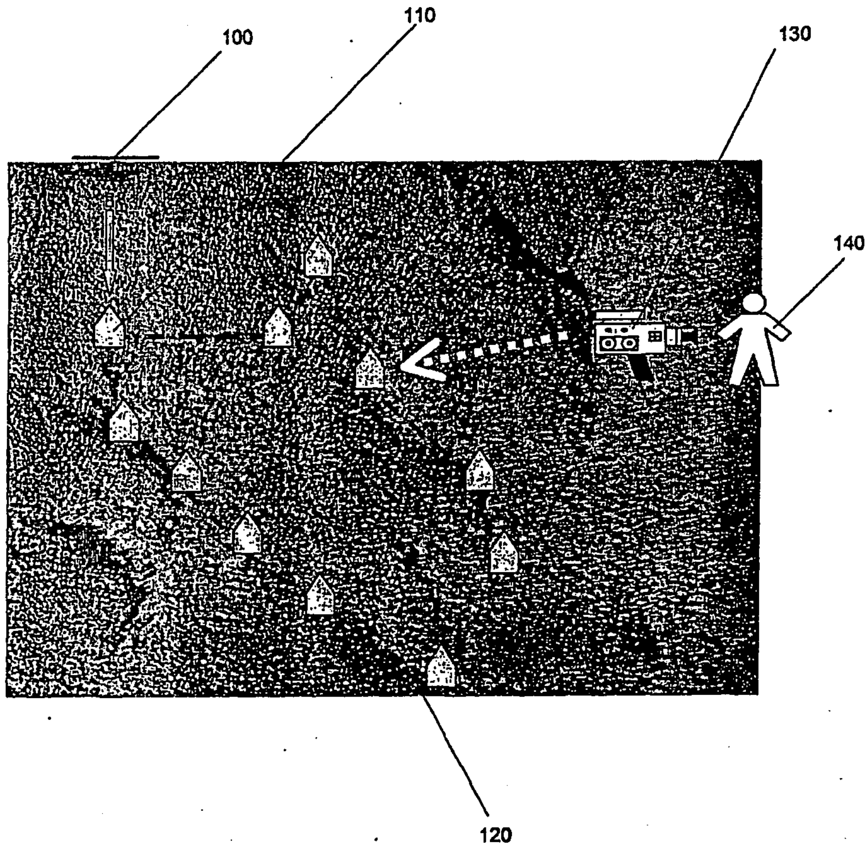

FIGURE 2

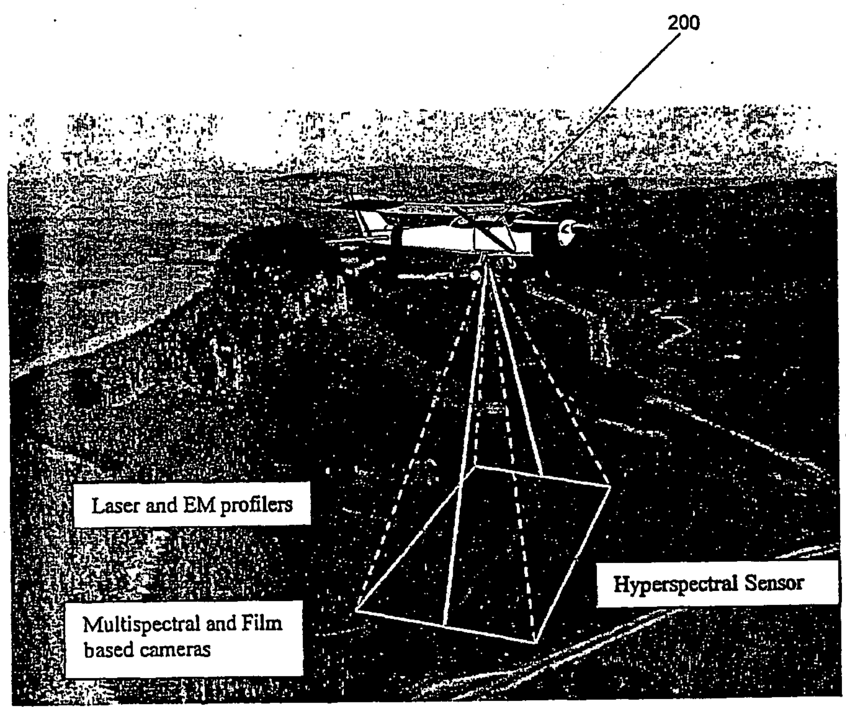
200
Laser and EM profilers
Hyperspectral Sensor
Multispectral and Film based cameras

FIGURE 3

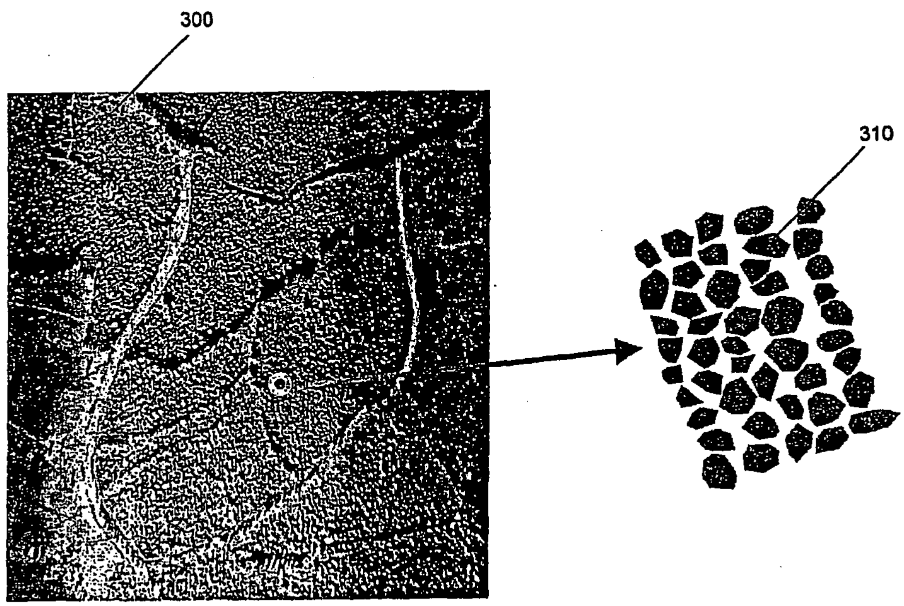

FIGURE 4

BEST AVAILABLE COPY

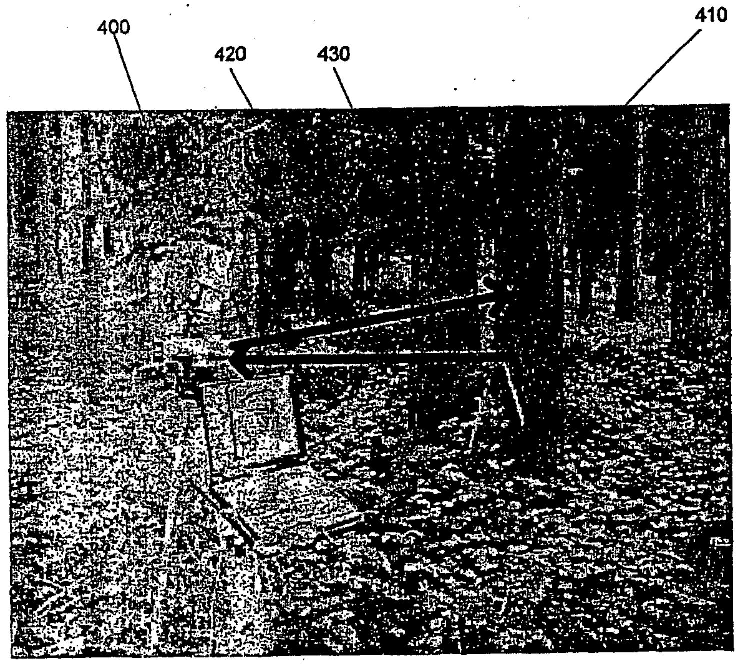

FIGURE 5

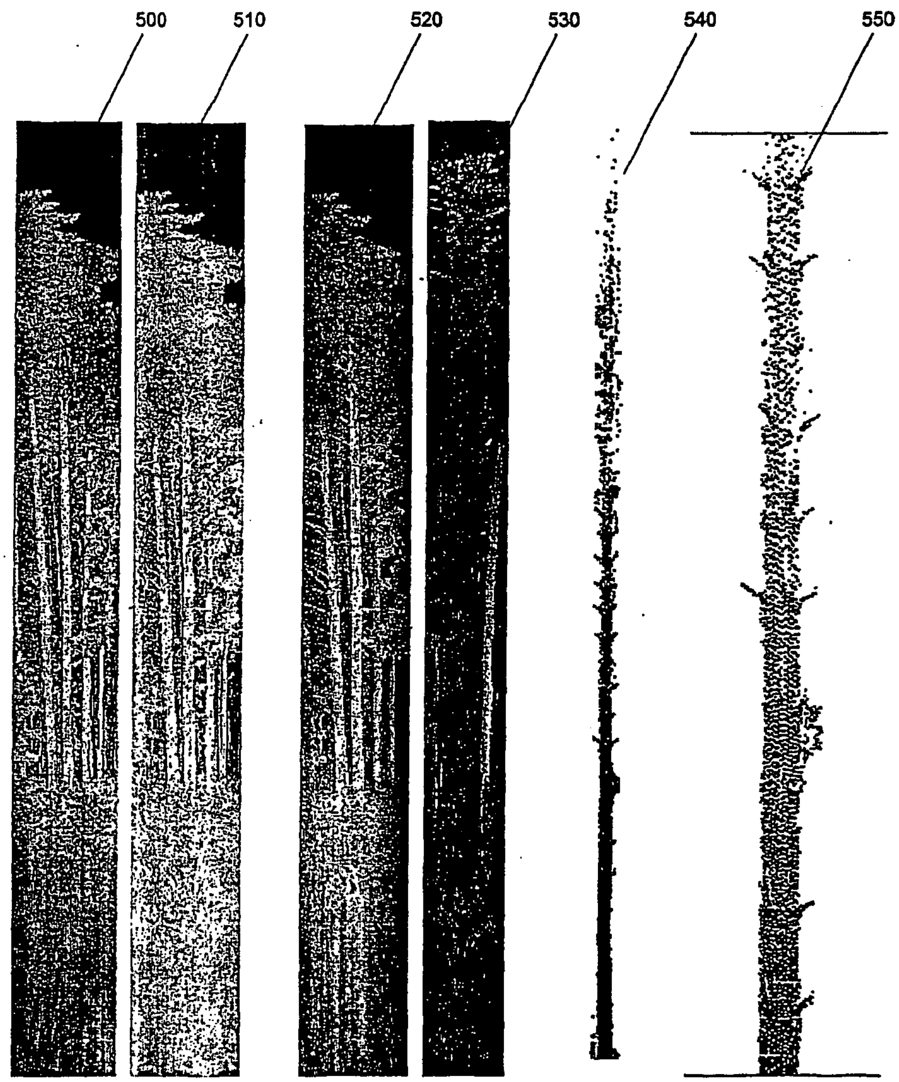

FIGURE 6

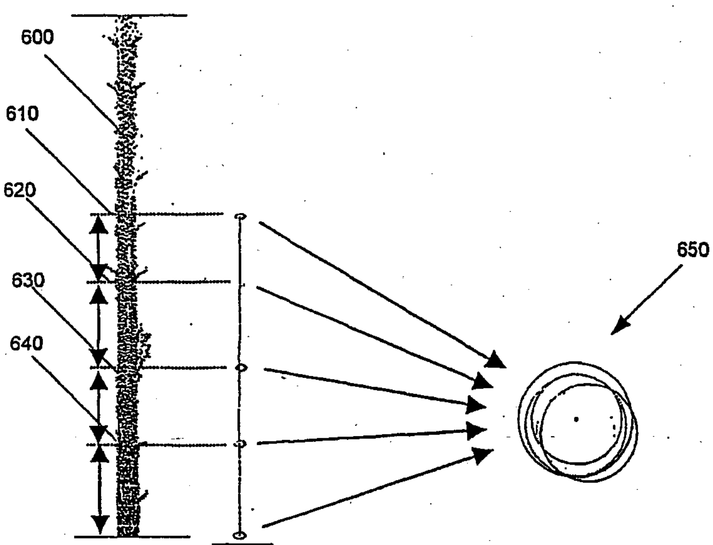

FIGURE 7

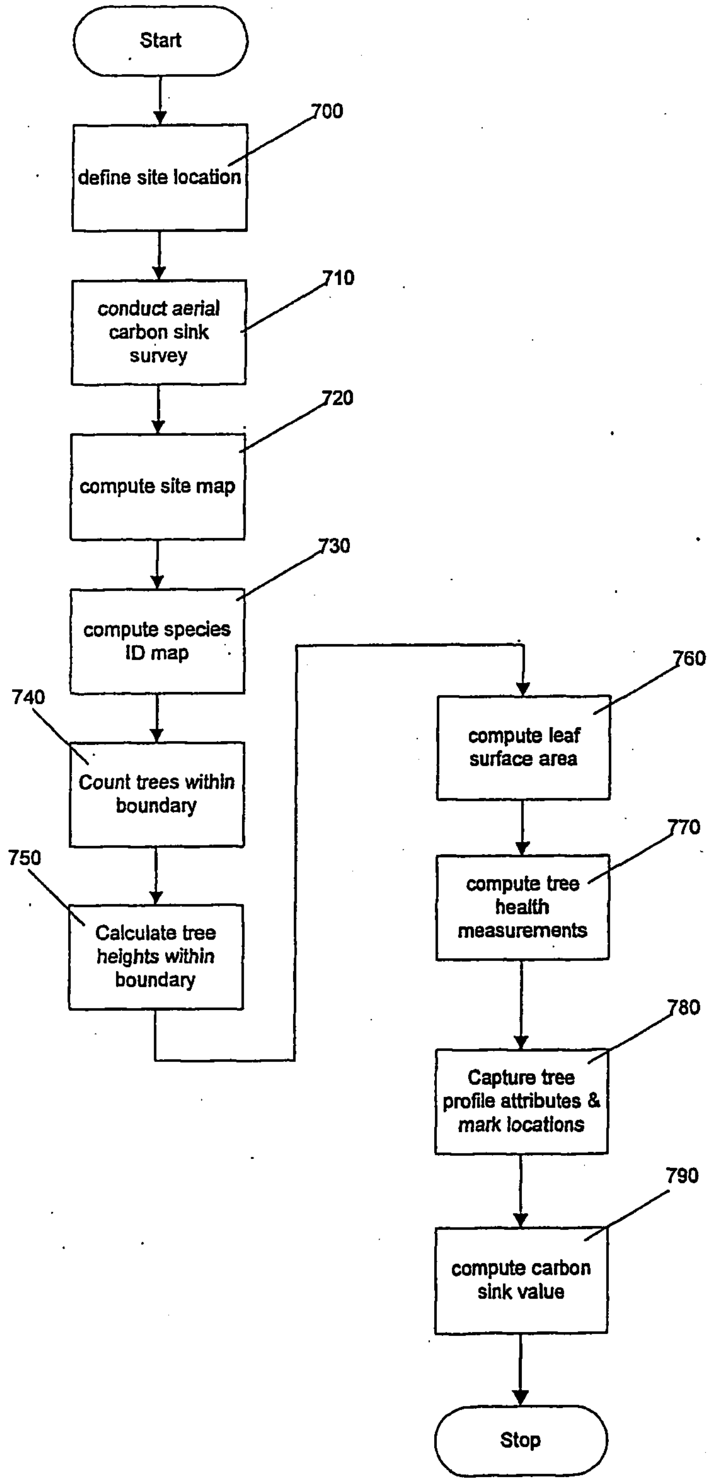
Start
700
define site location
710
conduct aerial carbon sink survey
720
compute site map
730
compute species ID map
740
Count trees within boundary
750
Calculate tree heights within boundary
760
compute leaf surface area
770
compute tree health measurements
780
Capture tree profile attributes & mark locations
790
compute carbon sink value
Stop

FIGURE 8

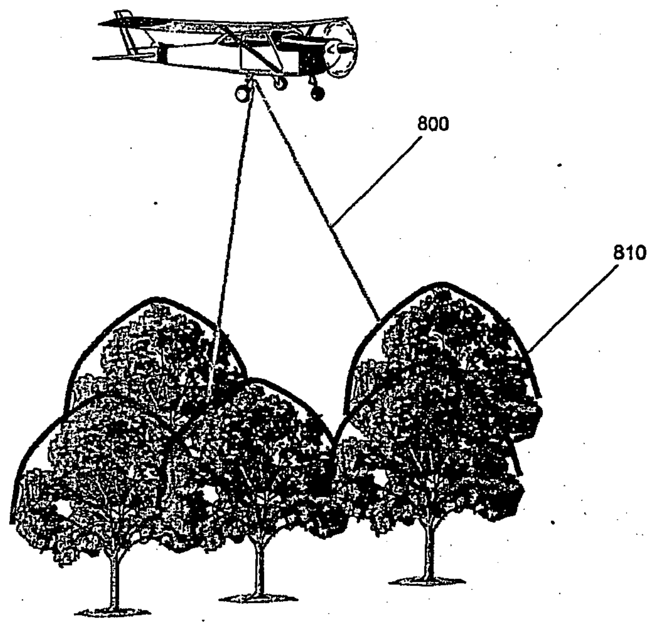

FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No. **PCT/NZ02/00035**

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: A01G 23/00, G01N 33/46, G01C 11/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DWPI, JAPIO, whole database with KEYWORDS ; tree? or woodland? or (wood-land?) or timberland? or (timber-land) or plantation?; assess+ or measur+ or determin+ or calculat+ or survey+ or estimat+; charateristic? propert+ or qualit+ or feature? or height? or volume?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Derwent Abstract Accession No.2001-101036/11, ClassP13;T01, RU 2156567A (UNIV MOSC FORESTRY) 27 September 2000. Abstract	1-4, 8-10
X	US 5886662 A (JOHNSON) 23 March, 1999 Col.5, lines 27-33, 52-65; col. 7, lines 23-26; col. 13, lines 26-55; Fig. 3.	1-10
P,X	WO 01/31290 A (DIWARE OY) 3 May 2001. Abstract; p5, line 26 - p6, line 16, Figs.	1-4,8-10

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2002	01 JUL 2002
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer M.HALL Telephone No : (02) 6283 2474

Box I **Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos :

   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos :

   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos :

   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II **Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

See supplemental sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:1-10

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No:II

The international application does not comply with the requirements of unity of invention because it does not relate to one invention or a group of inventions so linked as to form a general inventive concept. In coming to this conclusion the International Searching Authority has found that there are two inventions:

1. Claims 1-10 are directed to a method of assessing standing trees comprising a number of steps :

defining an area of forest for assessment,

calculating the number of trees within the defined area,

measuring the characteristics of one or more trees within the defined area,

defining the assessment indicator of the standing trees based on the number and the characteristics of the standing trees.

It is considered that the above combination of steps comprises a first " special technical feature".

2. Claims 11-15 are directed to a method or an apparatus for measuring the characteristics of one or more standing trees comprising the step of calculating a plurality of spatial coordinates defining the surface of at least part of the trees.

It is considered that the step of calculating a plurality of spatial coordinates defining the surface of at least part of the tree(s) comprises a second "special technical feature".

Since the above mentioned group of claims do not shared either of the technical features identified , a "technical relationship" between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/NZ02/00035

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
RU	2156567	NONE			
WO	200131290	AU	200111487	FI	992319
US	5886662	NONE			
					END OF ANNEX